A Preliminary Look at Factors Affecting Fiber Content of Oilseed Flax on the Prairies

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Abstract

The fiber content of oilseed flax straw has a very significant impact on the profitability of processing it into added value products. To date, there has been almost no published data on how flax straw fiber content varies in Western Canada and what factors are influencing this variation. In 2001, the bast fiber content in the straw from 16 oilseed flax varieties grown in replicated plots at 11 widely separated sites in Saskatchewan were compared as was the bast fiber content from three other sites where three oilseed varieties were grown in replicated plots with two seeding dates, three seeding rates and three nitrogen fertilizer rates. Many of the locations experienced the driest weather in the last 100 years and hence plant height, seed yield and fiber content were generally lower than normal. There were statistically significant differences between most of the locations and often between varieties at the same location. Some agronomic practices also had significant effects on fiber content. We do not know how much bias and misleading information was generated by the dry conditions. We must continue this type of study if we expect profitable flax straw processing plants to set up on the Prairies.

Introduction

From 350,000 to 450,000 ha of oilseed flax (*Linum usitatissimum*) are planted in Saskatchewan each year to produce seed for export. Between 800 to 1,200 kg/ha of straw could be collected after the seed is harvested. At present only 10-15% of this straw is collected and used in the manufacture of specialty papers and plastic composites. The straw that is not collected is either burnt or chopped and then spread on fields. Burning has negative environmental impacts and chopping and spreading has an economic cost.

There is increasing interest in utilizing the oilseed flax straw in Saskatchewan that is presently uncollected. However, processing this straw into industrial-grade fiber is not always profitable because of variations in fiber content.

The purpose of this study was to improve our understanding of the relationship between fiber content in oilseed flax grown in Saskatchewan and variety, location, date of seeding, rate of seeding and amount of nitrogen fertilizer so that farmers and straw processors can alter their management practices to increase their chance of producing profitable flax fiber based industries.

Method

Over 1,000 straw samples were collected from 14 widely separated research plot locations (i.e., the mostly widely separated locations were more than 800 km apart). The varieties, locations and agronomic treatments had already been chosen by other research projects that have been designed to increase the cost effectiveness of flax seed production for export. At each of 11 variety testing locations, each of 16 varieties was planted in three randomized replicated plots and, at each of three agronomic practice testing locations, each agronomic treatment was replicated three times using three varieties.

After the plot combine cut off the seed bolls as high as possible above the ground, straw from each plot in each trial was pulled out of the ground by hand. From each straw sample collected, a sub-sample bundle of straw 4.0 cm in diameter was selected. Each sub-sample bundle was then cut 10.0 cm above the ground level mark and 19.0 cm higher up resulting in bundles that were 19.0 cm in length. After cutting, each sub-sample was weighed and retted in a warm water tank for four to six days until the results of the "Fried Shake Test" (FST) showed that the majority of bundles were optimally retted. This FST involved placing 15 pieces of wet retting straw stems, each approximately 10.0 cm long, each from a different bundle, in separate glass test tubes half filled with boiling water. After putting stoppers in the top of all the tubes, they were inserted into a rocking/shaking machine designed by Biolin Research to violently shake tubes for exactly 45 seconds. The straw in each tube was then visually scored for loose fibers on a unit scale from "0" to "3" (0 = no loose fibers; 3 = total loosening of all bast fibers). When the average score was above 2.8, with no "0" scores and at least 12 tubes reaching a score of "3", the bundles in a batch were considered optimally retted.

The bundles were then taken out of the tank, rinsed, and dried in racks, by heater fans for approximately four days. The fiber was then extracted from each dried, retted sub-sample using a reciprocating blade-type breaker/decorticator. The fiber was hand cleaned to the point where few or no shives were left. After cleaning, the fiber was weighed. The percentage of bast fiber in the straw was calculated by taking the clean fiber weight, dividing by the weight of the unretted straw and multiplying by 100. Data from the trials were entered into Excel spreadsheets and regression equations were estimated, using binary variables to represent plot treatments. The results of the regression equations were used to identify the relationships that were statistically significant at the 95% confidence level.

Results

Straw from Variety Trials

Most locations experienced the driest weather of the last 100 years, hence plant height and seed yields were much lower than normal. Of the 11 sites compared (Table 1), only Assiniboia, Nipawin, Battleford, Carlyle and Wynyard had straw with fiber contents (i.e., 13-17%) close to the long-term range for oilseed flax (i.e., 15-25%). These more normal values were likely due to either higher rainfall or more soil moisture at these sites.

There were often significant differences in fiber content among varieties when compared at the same location (Table 1). Several varieties had superior fiber content at a majority of locations

(e.g., Taurus, Linola 1084, Emerson). A few varieties had superior fiber content in agroclimatically similar locations (e.g., CDC Valour in Area 2, AC Watson in Area 2 and Area 4). Conversely, some varieties had low fiber content in most locations (e.g., Bethune, FP1096); some had very low fiber in only a couple of agroclimatically similar locations (e.g., Arras, Lightning and Normandy). From a farmer's point of view, the most interesting are varieties which have superior seed yield and low fiber content (e.g., Bethune, FP1096) if there is no buyer for the flax straw. From the point of view of a processor who must buy flax straw from farmers, the most interesting varieties are those that have superior seed yield and superior fiber content (e.g., Taurus, Vimy, Flanders and Valour).

There were statistically significant differences in fiber content among most of the locations studied. These differences are likely due to differences in weather patterns and soil fertility. A regression equation combining results of all eleven variety test locations indicated that every location was statistically different. The four highest average fiber contents were at Assiniboia (17.2%), Nipawin (16.7%), Battleford (15.9%) and Carlyle (14.5%). The four poorest were Kernen (3.6%), Kelvington (7.8%), Girvin (10.8%) and Shellbrook (10.9%). Thus, average fiber content from the best location (Assiniboia) was 4.8 times greater than from the poorest location (Kernen). Combining the four best site averages gave a mean average 1.9 times greater than the mean of the four poorest sites.

Straw from Agronomic Trials

Straw was collected from three sites (Indian Head, Melfort, Morden) where three oilseed flax varieties (McDuff, Norlin, Valour) were grown in three randomized replicates and given different agronomic treatments. These included 67%, 100% and 133% of the recommended N along with three seeding rates (22, 45 and 67 kg/ha) plus early and late seeding. Combining fiber content data from all sites indicated statistically significant differences between each location with the mean at Indian Head being 9.1%, at Melfort being 14.4% and at Morden 15.1%. When all the data were combined, the only statistically significant variable was low seeding rate, which reduced fiber content from an average of 17.7% to 16.8%. Since combining data from all locations can mask some effects, comparisons were also made within locations. The following results were all statistically significant at the 95% level of confidence.

- At Indian Head, McDuff (9.2%) had lower fiber than Valour (10.8%) and Norlin (10.2%) and early seeding produced less fiber (8.3%) than later seeding (10.8%).

- At Melfort, Valour (14.9%) and McDuff (15.6%) had lower fiber than Norlin (16.3%); the 22 kg/ha seeding rate also produced less fiber (13.4%) than the 45 kg/ha seeding rate (14.9%). Similarly, early seeding produced less fiber (12.8%) than later seeding (14.9%).

- At Morden, the 22 kg/ha seeding rate reduced fiber content to 12.0% from the 45 kg/ha seeding rate fiber content of 12.7%, but unlike the other two locations, early seeding produced more fiber (17.0%) than later seeding (12.7%).

The above results are in general agreement with the values from straw analyzed from the variety trials that showed superior fiber content in one location does not always give superior fiber content at another location. Low seeding rates generally seem to cause a significant lowering of

fiber content. The effects of early seeding are unclear since, in some cases, there were positive effects and, in other cases, negative effects on fiber content.

The agronomic effects tested here may have been relatively muted due to the drought conditions in 2001 and because previous analysis of fiber content of the three varieties in this trial (McDuff, Norlin and Valour) by Plant Genetic Resources Canada in 1998 and 1999 showed that all three have low to medium fiber content, relative to other oilseed flax varieties that are, or have been, grown in Saskatchewan.

Conclusions

Many of the locations experienced the driest weather in the last 100 years and hence plant height, seed yield and fiber content were much lower than normal. There were statistically significant differences between most of the locations and often between varieties at the same location. Some agronomic practices had significant effects on fiber content. It is not possible from one year of data collection to estimate how much bias was generated by the exceptional drought conditions. The coefficient of variation (CV) of straw bast fiber contents was much higher than that commonly observed in seed yields of oilseed flax varieties. Given the variations in annual precipitation that occur at different locations in Saskatchewan, it will be important for processors of flax straw to be able to store high fiber content oilseed flax straw for several seasons to offset the low fiber content oilseed flax straw that is produced from time to time.

These preliminary results indicate that agronomic practices can influence fiber content. Therefore, farmers should be able to improve straw fiber content by adopting the correct practices. Several more years of testing at more locations will give a clearer understanding of the magnitude of these effects. For example, the date of seeding clearly has a significant effect on fiber content but the results to date have been contradictory. More trials will need to be carried out in different locations in Saskatchewan over a number of years to clarify why these contradictory effects occur.

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Table 1. Comparison of Oilseed Flax Fiber Contents and Seed Yields at 11 Locations in Saskatchewan in 2001
(Page 1 of 2 pages)

	Area 1 - Brown		Area 2 - Dark Brown								All Location MEAN	
	ASSINIBOIA		CARLYLE		GIRVIN		KERNAN		LUSELAND			
Variety	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)
Vimy	17.8%	1,894	14.6%	563	11.2%	1,603	3.8%	963	9.0%	1,132	**12.4%**	**1,312**
AC Carnduff	18.3%	1,712	15.0%	423	13.4%	1,497	4.5%	905	10.0%	1,158	**13.1%**	**1,219**
AC Emerson	18.0%	1,547	14.4%	464	11.3%	1,460	4.3%	774	14.2%	945	**13.2%**	**1,178**
AC Lightning	16.4%	1,795	12.6%	401	9.1%	1,639	3.2%	756	14.1%	1,283	**11.1%**	**1,310**
AC Watson	17.6%	1,584	15.2%	249	13.4%	1,366	3.7%	821	12.5%	1,161	**12.7%**	**1,197**
CDC Arras	16.7%	1,952	13.4%	314	9.9%	1,505	3.3%	944	10.1%	1,032	**11.4%**	**1,284**
CDC Bethune	16.0%	2,031	13.5%	853	7.4%	1,704	3.4%	905	12.6%	1,240	**10.8%**	**1,362**
CDC Normandy	16.1%	1,748	14.6%	816	10.1%	1,595	3.7%	760	13.5%	1,238	**11.8%**	**1,349**
CDC Valour	14.3%	1,919	15.5%	744	12.4%	1,678	4.7%	974	13.5%	1,218	**12.1%**	**1,376**
Flanders	18.5%	2,010	14.9%	497	9.3%	1,597	3.3%	956	12.7%	1,344	**12.2%**	**1,372**
FP1082	17.9%	1,429	16.0%	597	9.3%	1,353	3.8%	704	6.6%	745	**12.0%**	**1,045**
FP1094	17.4%	1,770	14.6%	282	9.2%	1,490	2.9%	865	14.5%	1,307	**11.8%**	**1,250**
FP1096	16.2%	1,724	13.1%	199	7.8%	1,448	2.1%	854	8.1%	1,230	**10.2%**	**1,244**
Linola™ 989	16.5%	1,635	13.6%	379	11.6%	1,452	2.5%	757	13.0%	1,067	**12.3%**	**1,186**
Linola™ 1084	19.3%	1,743	14.5%	597	14.4%	1,500	4.1%	883	8.8%	1,116	**13.7%**	**1,260**
Taurus	17.7%	1,890	16.2%	818	12.6%	1,597	4.1%	837	9.8%	1,148	**13.1%**	**1,381**
CV /a	32.6%	6.2%	45.8%	23.1%	40.0%	7.1%	63.7%	9.9%	59.1%	9.2%	**54.9%**	**11.9%**
Average	17.2%	1,774	14.5%	512	10.8%	1,530	3.6%	854	11.4%	1,148	**12.1%**	**1,270**

a/ This CV has been calculated by taking the CV of the CVs of each individual variety within each location.

NOTES: Fiber content is the retted fiber weight as a percentage of unretted straw.

Seed data supplied by the University of Saskatchewan Crop Development Centre

No shading denotes high fiber % and high seed yield relative to the average at each site

Table 1. Comparison of Oilseed Flax Fiber Contents and Seed Yields at 11 Locations in Saskatchewan in 2001

	Area 3 - Black						Area 4 - Moist Black					
	BATTLEFORD		ROSTHERN		WYNYARD		KELVINGTON		NIPAWIN		SHELLBROOK	
Variety	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)	Fiber Content (%)	Seed Yield (kg/ha)
Vimy	17.1%	2,338	12.6%	1,256	14.3%	1,986	8.0%	1,406	18.8%	657	9.3%	633
AC Carnduff	17.7%	2,199	10.9%	1,161	14.4%	1,831	10.3%	1,374	18.5%	546	11.3%	608
AC Emerson	16.0%	2,189	13.2%	1,184	14.6%	1,822	7.4%	1,352	17.3%	596	14.7%	625
AC Lightning	13.7%	2,295	9.1%	1,091	11.5%	1,997	6.7%	1,394	16.8%	828	9.0%	928
AC Watson	15.2%	2,125	10.8%	1,169	14.3%	1,860	8.2%	1,318	17.8%	799	11.0%	711
CDC Arras	15.7%	2,236	11.7%	1,276	12.1%	1,914	6.5%	1,346	15.3%	863	10.0%	741
CDC Bethune	15.5%	2,425	11.7%	1,206	11.6%	1,783	5.8%	1,597	13.1%	652	8.2%	583
CDC Normandy	14.1%	2,221	10.3%	1,390	12.6%	1,832	7.4%	1,456	17.3%	935	10.6%	846
CDC Valour	15.2%	2,379	11.5%	1,429	13.2%	1,818	6.2%	1,587	17.1%	682	9.2%	704
Flanders	15.6%	2,356	11.5%	1,253	13.9%	1,871	8.5%	1,608	15.3%	807	11.0%	795
FP1082	18.2%	2,247	10.6%	912	14.1%	1,802	8.5%	991	15.7%	289	10.9%	427
FP1094	15.0%	2,244	8.9%	923	13.8%	1,891	7.0%	1,356	15.7%	881	10.6%	739
FP1096	13.8%	2,240	8.4%	959	10.8%	1,767	5.6%	1,467	15.9%	761	10.3%	1,034
Linola™ 989	14.3%	2,138	10.7%	1,040	15.1%	1,664	8.9%	1,419	17.6%	744	11.4%	751
Linola™ 1084	19.1%	2,328	12.0%	1,055	15.1%	1,432	10.2%	1,460	19.6%	907	14.0%	836
Taurus	17.7%	2,372	13.3%	1,458	14.3%	2,061	9.2%	1,451	16.1%	750	12.5%	807
CV /a	47.8%	6.0%	58.5%	10.1%	43.5%	9.4%	61.5%	11.8%	58.2%	19.3%	93.6%	18.6%
Average	15.9%	2,271	11.1%	1,173	13.5%	1,833	7.8%	1,411	16.7%	731	10.9%	736

a/ This CV has been calculated by taking the CV of the CVs of each individual variety within each location.

NOTES: Fiber content is the retted fiber weight as a percentage of unretted straw.

Seed data supplied by the University of Saskatchewan Crop Development Centre

No shading denotes high fiber % and high seed yield relative to the average at each site